School-age Outcomes of Extremely Preterm or Extremely Low Birth Weight Children

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KEY WORDS academic achievement, IQ, low birth weight, neurobehavior, preterm

ABBREVIATIONS CI—confidence interval
ELBW—extremely low birth weight
EP—extremely preterm
FSIQ—full-scale IQ
GA—gestational age
PRI—Perceptual Reasoning Index
SDQ—Strengths and Difficulties Questionnaire
T/NBW—term/normal birth weight
VCI—Verbal Comprehension Index
WISC-IV—Wechsler Intelligence Scale for Children, Fourth Edition
WRAT3—Wide Range Achievement Test, Third Edition

Dr Hutchinson drafted the initial manuscript; conducted the analyses, reviewed and revised the manuscript, and approved the final manuscript as submitted; Dr De Luca contributed to the initial manuscript, reviewed and revised the manuscript, and approved the final manuscript as submitted, Dr Roberts critically reviewed and revised the manuscript, and approved the final manuscript as submitted; Dr Doyle conceptualized and designed the study, reviewed and revised the manuscript, and approved the final manuscript as submitted; Dr Anderson conceptualized and designed the study, reviewed and revised the manuscript, and approved the final manuscript as submitted.

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WHAT’S KNOWN ON THIS SUBJECT: Although it is known that extremely preterm children are at increased risk for cognitive deficits, academic underachievement, and behavioral problems, the frequency and severity of these impairments may decline with advances in neonatal care.

WHAT THIS STUDY ADDS: Despite recent changes in obstetric and neonatal management of extremely preterm infants, the rate of neurobehavioral impairments at school age is still too high.

abstract

OBJECTIVE: Research is required to monitor changes in the nature of neurobehavioral deficits in extremely preterm (EP) or extremely low birth weight (ELBW) survivors. This study examines cognitive, academic, and behavioral outcomes at age 8 years for a regional cohort of EP/ELBW children born in 1997.

METHODS: The EP/ELBW cohort comprised all live births with a gestational age <28 weeks (EP) or birth weight <1000 g (ELBW) born in the state of Victoria, Australia, in 1997. Of 317 live births, 201 (63.4%) survived to 2 years of age. A term/normal birth weight (T/NBW) cohort was recruited comprising 198 infants with birth weights <2500 g or gestational age <37 weeks. Measures of intellectual ability, educational achievement, and behavior were administered at age 8.

RESULTS: Retention was 94% for the EP/ELBW group and 87% for the T/NBW group. The EP/ELBW group performed poorer than the T/NBW group on measures of IQ, educational achievement, and certain behavioral domains, even after adjustment for sociodemographic factors and exclusion of children with neurosensory impairment. The rate of any neurobehavioral impairment was elevated in the EP/ELBW group (71% vs 42%), and one-half of subjects had multiple impairments. The outcomes for those with <750 g birth weight or <26 weeks’ gestational age were similar to those with a birth weight of 750 to 999 g or a gestational age of 26 to 27 weeks, respectively.

CONCLUSIONS: Despite ongoing improvements in the management of EP/ELBW infants, the rate of neurobehavioral impairment at school-age remains too high relative to controls. PEDIATRICS 2013;131:e1053–e1061
In the past, cognitive deficits, academic underachievement, and behavioral problems have occurred more frequently in school-aged children born extremely preterm (EP; <28 weeks’ gestational age [GA]) and/or extremely low birth weight (ELBW; <1000 g) compared with children born at term or of normal birth weight. Changes in obstetric and neonatal management of high-risk pregnancies and infants occur constantly, with reductions in mortality and short-term morbidity, especially for infants at the edge of viability. Treatments associated with short-term neurologic benefits include antenatal administration of magnesium sulfate, caffeine for the treatment of apnea of prematurity, and high-dose docosahexaenoic acid supplementation, the first 2 of which are now routine treatments in Australia and the third is used in some units. There is also growing evidence that early-intervention programs enhance the development of preterm infants. Accordingly, the frequency, nature, and severity of neurobehavioral deficits observed in contemporary cohorts of EP/ELBW children may differ from those of earlier eras.

The aim of the current study was to investigate cognitive, academic, and behavioral outcomes at age 8 years for a cohort of children born EP or ELBW in 1997. In contrast to most previous published reports of long-term outcome, not only is our study more contemporary, it also reports on a geographic cohort, includes a matched term/normal birth weight (T/NBW) group, and achieves high retention.

METHODS

The EP/ELBW cohort comprised all live births with either a GA <28 weeks or birth weight <1000 g born in the state of Victoria, Australia, in 1997. Survivors received neonatal care in 1 of the 4 NICUs in the state and were enrolled in this longitudinal study in the newborn period. Of 317 eligible live births, 201 (63.4%) survived to 2 years of age.

The T/NBW cohort, recruited in the same time period, comprised 199 infants with a GA ≥37 weeks or birth weight ≥2500 g, all of whom survived to age 2 years. These children were randomly selected from births on the expected date of birth for each EP/ELBW child and matched for gender, mother’s country of birth (English speaking or not), and health insurance status (private health insurance or not). Written informed consent was obtained.

The study was approved by the Human Research Ethics Committees at the Royal Women’s Hospital, Mercy Hospital for Women, and Monash Medical Centre, Victoria, Australia. Psychologists performing assessments were unaware of the history and group status of the children. Outcome data at 2 years have previously been reported.

General Intellectual Ability

General intellectual ability was assessed by using the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV). Full-scale IQ (FSIQ) was used as a measure of general intelligence, and the 4 index scores provide information on more specific cognitive domains. The Verbal Comprehension Index (VCI) measures knowledge of word meanings and verbal reasoning abilities, the Perceptual Reasoning Index (PRI) measures visuconstruc
tional skills and visual reasoning abilities, the Working Memory Index measures immediate and working memory, and the Processing Speed Index measures speed and accuracy of information processing. Each index score is age standardized, with a mean of 100 and an SD of 15. Cognitive impairment was classified according to both test norms and the T/NBW distribution.

Children unable to attempt the WISC-IV due to severe disability (n = 3) were assigned FSIQ and index scores of 40 (4 SDs). Children with severe visual impairment who could not be administered tests with visual stimuli (n = 2) were assigned an FSIQ based on their VCI score. One child with significant hearing impairment was not administered tests with significant language demands, and an FSIQ was assigned according to their PRI score. All these children were in the EP/ELBW cohort.

Academic Skills

Academic abilities were assessed by using the Wide Range Achievement Test, Third Edition (WRAT3). The WRAT3 comprises reading (single word decoding), spelling, and arithmetic subtests. Each scale has a mean of 100 and an SD of 15, and impairment was classified according to both test norms and the T/NBW distribution.

Children with either WISC-IV or WRAT3 standard scores from −1 to −2 SDs relative to the normative mean or the T/NBW mean were classified as mildly impaired, whereas those with scores −2 or lower SDs relative to the normative mean or the T/NBW mean were considered to have a major impairment.

Behavioral Outcomes

Behavioral outcomes were assessed by using the Strengths and Difficulties Questionnaire (SDQ). This 25-item, parent-rated questionnaire has 5 scales: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behavior. Twenty of the items are combined to generate a “total difficulties” score, and an “impact” score is produced from items that ask about the effect of these difficulties on the child (level of distress; impact on home, friendships, classroom, and leisure).

Normative data for children (www.sdqinfo.org) were used to determine those in the clinical range. Children
with scores above the 90th percentile were classified as being in the “abnormal” range, those between the 80th and 90th percentile were classified as “borderline,” and those below the 80th percentile were classified as “normal.” Children were also classified into these clinical categories according to cutoffs based on the T/NBW distribution.

Sociodemographic Factors

Sociodemographic information was collected at 8 years, including marital status of mother (married or single), language spoken at home (English only or other), maternal and paternal education (≥12 years of education or <12 years of education), family structure (intact or other), and occupation of the primary income earner (skilled/semiskilled or unskilled/unemployed).

Statistical Analyses

Group differences were contrasted by using t tests for continuous data, χ² analysis for dichotomous data, and χ² tests for linear trends for ordered dichotomous variables. The magnitude of group differences on WISC-IV and WRAT3 indices was calculated by dividing the group difference by the published normative SD for those indices. Analyses were repeated excluding children with neurosensory impairment (eg, cerebral palsy, deafness, blindness). Analysis of covariance was then undertaken to control for the potential impact of sociodemographic factors (gender, marital status, language spoken at home, mother’s and father’s educational level, family structure, and occupation of primary income earner) on cognitive, academic, and behavioral outcomes. Subgroup analyses were performed comparing the smallest (birth weight, <750 g) and most preterm (<26 weeks’ GA) children and the slightly heavier (750–999 g) and older (26–27 weeks’ GA) children. An α level was set at .05 for all analyses, and no adjustment was made for multiple comparisons because the outcomes parameters are not independent.16

RESULTS

Follow-up rates were 94% (189 of 201) for the EP/ELBW group and 87% (173 of 199) for the T/NBW group. Of the 12 EP/ELBW children not seen, 10 were assessed at 2 years’ corrected age. EP/ELBW participants and nonparticipants at 8 years did not differ on the Mental Development Index of the Bayley Scales of Infant Development (BSID-II) at 2 years (mean difference, −4.2 [95% confidence interval (CI), −18.0 to 9.7], P = .55). Eighteen of the 26 T/NBW children not seen were assessed at 2 years of age. No difference was found between T/NBW participants and nonparticipants on the Mental Development Index (mean difference, −0.2 [95% CI, −7.9 to 7.6], P = .97).

Table 1 displays perinatal and sociodemographic characteristics of the groups. Of the EP/ELBW cohort, 61 children (32%) were born <26 weeks’ GA and 62 (33%) weighed <750 g. Antenatal corticosteroids were administered for the majority of EP/ELBW infants, and approximately one-third received postnatal corticosteroids. Cystic periventricular leukomalacia or grade 3/4 intraventricular hemorrhage were observed in a small number. The gender and age-at-assessment distributions for the EP/ELBW and T/NBW groups were similar. Although no child in the T/NBW group was small for gestational age (birth weight less than −2 SDs), 18% of the EP/ELBW group fell within this category (χ² = 34.3, P < .001). Family structure, maternal marital status, and language spoken at home did not differ between groups. In contrast, parents of EP/ELBW children were less likely to have completed 12 years of schooling than parents of T/NBW children (mothers, χ² = 11.6, P = .001; fathers, χ² = 14.4, P < .001), and the primary income earner in EP/ELBW families was more likely to be unskilled (χ² = 17.5, P < .001).

When seen at age 8 years, 29 (15%) children in the EP/ELBW cohort had neurosensory impairment; 3 were blind, 4 required hearing aids, and 24 had cerebral palsy (1 child with cerebral palsy was also blind and another child was also deaf). In the T/NBW cohort, no child had a neurosensory impairment.

### Table 1. Perinatal and Sociodemographic Characteristics of the EP/ELBW and T/NBW Groups

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>EP/ELBW (n = 188)</th>
<th>T/NBW (n = 173)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perinatal characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>100 (52.9)</td>
<td>92 (53.2)</td>
<td>.96</td>
</tr>
<tr>
<td>GA, mean ± SD, completed wk</td>
<td>26.5 ± 2.0</td>
<td>39.3 ± 1.1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Birth weight, mean ± SD, g</td>
<td>833 ± 164</td>
<td>3506 ± 1455</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Birth weight less than −2 SDs</td>
<td>34 (18.0)</td>
<td>0 (0)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Age at evaluation, mean ± SD, y</td>
<td>8.45 ± 0.41</td>
<td>8.50 ± 0.39</td>
<td>.10</td>
</tr>
<tr>
<td>Antenatal corticosteroids</td>
<td>166 (87.8)</td>
<td>2 (1.2)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Surfactant</td>
<td>154 (81.5)</td>
<td>1 (0.6)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Postnatal corticosteroids</td>
<td>70 (37.0)</td>
<td>0 (0)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Oxygen dependency at 36 wk</td>
<td>72 (38.1)</td>
<td>0 (0)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Cystic periventricular leukomalacia</td>
<td>6 (3.2)</td>
<td>0 (0)</td>
<td>.02</td>
</tr>
<tr>
<td>Grade 3/4 intraventricular hemorrhage</td>
<td>7 (3.7)</td>
<td>0 (0)</td>
<td>.03</td>
</tr>
<tr>
<td>Sociodemographic characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English only spoken at home</td>
<td>150/186 (80.6)</td>
<td>147/171 (86.0)</td>
<td>.18</td>
</tr>
<tr>
<td>Intact family structure</td>
<td>131/169 (77.5)</td>
<td>138/165 (84.2)</td>
<td>.12</td>
</tr>
<tr>
<td>Married mother</td>
<td>136/169 (80.5)</td>
<td>128/159 (80.5)</td>
<td>.99</td>
</tr>
<tr>
<td>Primary income earner skilled/semiskilled</td>
<td>96/171 (56.1)</td>
<td>125/161 (77.6)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Maternal education (≥12 y of schooling)</td>
<td>94/188 (48.7)</td>
<td>116/172 (67.4)</td>
<td>.001</td>
</tr>
<tr>
<td>Paternal education (≥12 y of schooling)</td>
<td>71/177 (40.1)</td>
<td>99/163 (60.7)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Data are presented as number (percent) unless otherwise indicated.
General Intellectual Ability
The mean FSIQ for the EP/ELBW group was significantly below that of the T/NBW cohort, with the magnitude of the group difference exceeding 0.8 SD (t = –8.2, P < .001). The same pattern was evident for the index scores, with EP/ELBW children performing between 0.4 to 0.8 SD below the T/NBW group (Table 2): verbal comprehension (t = –7.1, P < .001), perceptual reasoning (t = –7.7, P < .001), working memory (t = –5.5, P < .001) and processing speed (t = –4.3, P < .001).

Controlling for sociodemographic variables marginally reduced the mean group difference on these WISC-IV scales, and all comparisons remained highly significant. Statistical conclusions also remained unchanged when children with neurosensory disabilities were excluded.

Academic Progress
The EP/ELBW group performed significantly below the T/NBW group on tests of reading (t = –4.71, P < .001), spelling (t = –4.69, P < .001), and arithmetic (t = –5.40, P < .001). The magnitude of the group differences was 0.5 SD for reading and spelling but slightly higher for arithmetic (0.6 SD). Mean differences between the groups on academic tests remained significant after adjusting for sociodemographic variables and excluding those with neurosensory impairment.

Behavioral Problems (SDQ)
Parents of children in the EP/ELBW group reported more behavioral problems than those of the T/NBW group (t = 25.5, P < .001), with these difficulties having greater impact (t = 2.5, P = .013). EP/ELBW parents reported that their children were displaying more hyperactivity/inattention (t = 3.9, P < .001), emotional problems (t = 5.42, P < .001), and peer relationship problems (t = 2.85, P = .005) compared with control children. Results were robust, with group differences remaining stable after adjusting for sociodemographic variables and excluding those with neurosensory impairment.

TABLE 2
Cognitive and Academic Outcomes (Mean ± SD) for the EP/ELBW and T/NBW Cohorts at 8 Years of Age, Including Adjustment for Sociodemographic Variables and Neurosensory Impairment

<table>
<thead>
<tr>
<th>Outcome</th>
<th>EP/ELBW (n = 188)</th>
<th>Controls (n = 173)</th>
<th>Mean Difference (95% CI)</th>
<th>Adjusted Mean Difference 95% CI</th>
<th>Adjusted Mean Difference 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>WISC-IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FSIQ</td>
<td>93.1 ± 16.1</td>
<td>105.6 ± 12.4</td>
<td>–12.5 (–15.5 to –9.5)*</td>
<td>–10.2 (–13.7 to –6.6)*</td>
<td>–8.8 (–12.2 to –5.3)*</td>
</tr>
<tr>
<td>Verbal comprehension</td>
<td>93.1 ± 14.3</td>
<td>103.2 ± 12.6</td>
<td>–10.2 (–13.0 to –7.4)*</td>
<td>–7.8 (–11.1 to –4.5)*</td>
<td>–7.0 (–10.2 to –3.9)*</td>
</tr>
<tr>
<td>Perceptual reasoning</td>
<td>95.9 ± 16.8</td>
<td>108.2 ± 12.8</td>
<td>–12.3 (–15.4 to –9.2)*</td>
<td>–10.1 (–13.9 to –6.4)*</td>
<td>–8.0 (–11.5 to –4.7)*</td>
</tr>
<tr>
<td>Working memory</td>
<td>94.0 ± 16.3</td>
<td>102.4 ± 12.9</td>
<td>–8.5 (–11.6 to –5.4)*</td>
<td>–7.1 (–10.9 to –3.4)*</td>
<td>–6.1 (–9.7 to –2.6)**</td>
</tr>
<tr>
<td>Processing speed</td>
<td>94.7 ± 15.9</td>
<td>101.1 ± 11.9</td>
<td>–6.4 (–9.4 to –3.5)*</td>
<td>–5.7 (–9.3 to –2.3)**</td>
<td>–4.3 (–7.7 to –1.0)**</td>
</tr>
<tr>
<td>WATR-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>98.0 ± 16.1</td>
<td>105.5 ± 13.8</td>
<td>–7.6 (–10.7 to –4.4)*</td>
<td>–6.7 (–10.4 to –3.0)*</td>
<td>–6.7 (–10.4 to –3.0)*</td>
</tr>
<tr>
<td>Spelling</td>
<td>96.8 ± 15.2</td>
<td>104.2 ± 14.4</td>
<td>–7.5 (–10.6 to –4.3)*</td>
<td>–7.4 (–11.1 to –3.8)*</td>
<td>–7.7 (–11.5 to –4.0)*</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>90.0 ± 16.8</td>
<td>99.1 ± 14.5</td>
<td>–9.2 (–12.5 to –5.8)*</td>
<td>–8.9 (–11.2 to –2.9)**</td>
<td>–6.8 (–10.9 to –2.8)**</td>
</tr>
<tr>
<td>SDQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11.0 ± 6.3</td>
<td>7.9 ± 5.4</td>
<td>3.1 (1.9 to 4.4)*</td>
<td>3.3 (2.0 to 4.6)*</td>
<td>3.4 (2.0 to 4.7)*</td>
</tr>
<tr>
<td>Emotional symptoms</td>
<td>2.9 ± 2.4</td>
<td>1.7 ± 1.7</td>
<td>1.2 (0.8 to 1.6)*</td>
<td>1.2 (0.7 to 1.7)*</td>
<td>1.2 (0.7 to 1.7)*</td>
</tr>
<tr>
<td>Conduct problems</td>
<td>1.7 ± 1.7</td>
<td>1.4 ± 1.5</td>
<td>0.3 (–0.1 to 0.6)</td>
<td>0.3 (–0.1 to 0.6)</td>
<td>0.3 (–0.1 to 0.7)</td>
</tr>
<tr>
<td>Hyperactivity/inattention</td>
<td>4.3 ± 2.7</td>
<td>3.2 ± 2.5</td>
<td>1.1 (0.5 to 1.6)*</td>
<td>1.3 (0.7 to 1.9)*</td>
<td>1.3 (0.7 to 1.9)*</td>
</tr>
<tr>
<td>Peer relationships</td>
<td>2.1 ± 2.1</td>
<td>1.5 ± 1.8</td>
<td>0.6 (0.2 to 1.0)**</td>
<td>0.7 (0.2 to 1.1)**</td>
<td>0.6 (0.2 to 1.1)**</td>
</tr>
<tr>
<td>Prosocial behavior</td>
<td>8.3 ± 1.9</td>
<td>8.6 ± 1.7</td>
<td>–0.3 (–0.7 to –0.0)</td>
<td>–0.3 (–0.7 to –0.1)</td>
<td>–0.4 (–0.8 to 0.1)</td>
</tr>
<tr>
<td>Impact</td>
<td>1.1 ± 1.9</td>
<td>0.8 ± 1.4</td>
<td>0.3 (0.1 to 0.8)**</td>
<td>0.4 (0.1 to 0.8)**</td>
<td>0.3 (–0.1 to 0.7)</td>
</tr>
</tbody>
</table>

* Adjusted for demographic variables.
** Adjusted for demographic variables, with children with neurosensory impairment excluded.
*** P < .001.
* P < .01.
** P < .05.

Birth Weight and GA
For the EP/ELBW sample, the <750-g subgroup displayed lower performances on all cognitive scales than the ≥750- to 999-g subgroup, but only differences in VCI and PRI reached significance (Table 3). Significant differences were also demonstrated across all academic measures. However, when comparisons were adjusted for neurosensory impairment, significant differences were lost for spelling and arithmetic. No differences were seen on any of the SDQ behavior scales.

The <26-week GA subgroup achieved lower scores on cognitive and academic scales than the 26- to 27-week GA subgroup, although only performance on the PRI reached significance. When comparisons were adjusted for neurosensory impairment, the significant difference between groups on the PRI was lost. In relation to the behavioral outcomes, parents of children in the
26- to 27-week GA subgroup reported more emotional problems compared with the <26-week GA subgroup, but there were no other significant differences.

**Rates of Neurobehavioral Impairment**

Ratios of cognitive, academic, or behavioral impairment were significantly elevated in the EP/ELBW group when judged according to either test norms or the T/NBW distribution (Table 4).

Based on the T/NBW group distribution, 71% of EP/ELBW children had at least 1 mild to severe neurobehavioral impairment, with 47% exhibiting ≥2 impairments (Table 5). In contrast, 42% of the T/NBW group had at least 1 neurobehavioral impairment, with only 16% exhibiting ≥2 impairments.

The actual rates of impairment were lower when based on test norms, but again the EP/ELBW group had higher impairment rates than the T/NBW group.

**Discussion**

Our EP/ELBW cohort performed significantly below T/NBW peers on all cognitive and academic domains assessed and were elevated on most behavioral scales (reflective of greater difficulties), consistent with previous research. Our findings were robust and remained significant after adjusting for sociodemographic factors and excluding children with neurosensory impairment. In accordance with these results, the EP/ELBW cohort exhibited higher rates of impairments across all domains than the T/NBW cohort. We report impairment rates according to both the T/NBW distribution as well as test norms due to the secular shift in test norms for measures of general intelligence. Our group and others have previously demonstrated that the rate of impairment may be significantly underestimated when determined according to test norms in contrast to local controls. and, as expected, we found the overall impairment rate to be substantially higher when judged according to the local control group's distribution. Alarmingly, 71% of the EP/ELBW group had at least 1 mild to severe neurobehavioral impairment, with 47% having multiple impairments. However, this rate needs to be interpreted in context, with 42% of the T/NBW group exhibiting at least 1 impairment and 16% displaying multiple problems.

The IQ of our EP/ELBW cohort was 0.8 SD below the T/NBW cohort (adjusted, -0.6 SD). For a cohort born in 1991–1992 in the identical geographic region and assessed by using similar recruitment and follow-up procedures, the group difference in IQ at age 8 years was...
slightly lower (unadjusted, −0.6 SD; adjusted, −0.5). Thus, no improvement in IQ is obvious between the early and late 1990s in the state of Victoria, although it should be noted that the survival rate for the 1997 cohort was higher (63% vs 53%) and included more children born at <26 weeks’ GA (34% vs 27%) and with birth weights <750 g (33% vs 20%). The findings from the current study are consistent with a meta-analysis of studies of subjects born before the 1990s, which reported an IQ deficit in the preterm/LBW population of 11 points (0.7 SD),20 and a more recent review of VP/VLBW population-based studies, which found that in most cases, the mean IQ deficit ranged from 9 to 13 points.21 A gradient effect has been described in very preterm populations, with IQs declining by 1.7 to 2.5 points with each week’s decrease in GA.20,21 In the current study, the <750-g subgroup had a significantly lower IQ than their heavier EP/ELBW peers, and although failing to reach statistical significance, the <26-week GA subgroup had a lower IQ than the 26- to 27-week GA subgroup.

With regard to WISC-IV indices, the EP/ELBW cohort scored significantly lower than the T/NBW cohort across all domains, suggesting a global cognitive deficit rather than impairments in selective domains, and this result is consistent with our findings in the Victorian Infant Collaborative Study Group (VICS) 1991–1992 cohort.2 More refined neuropsychological testing may reveal cognitive domains of greater vulnerability; however, current research supports the notion of a global cognitive deficit, with impairments reported in motor skills,22 processing speed,23 attention,24 memory and learning,25 language,26 and executive function.27

Academic difficulties are consistently reported in EP and VLBW (<1500 g) cohorts.28,29 The rates of reading and spelling impairment in our EP/ELBW cohort were approximately double the rate observed in the T/NBW cohort. Literacy skills do not seem to be improving in more contemporary EP/ELBW cohorts: the group differences and rates of impairment were marginally lower in the VICS 1991–1992 cohort.2 As reported previously,2,29,30 concerns were even greater for the EP/ELBW cohort with regard to arithmetic, as this group scored 0.6 SD below their T/NBW peers. Given the difficulties EP/ELBW children have acquiring rudimentary academic skills, further research is needed to determine the basis for these learning deficits.

### TABLE 4: Rates of Cognitive, Academic, and Behavioral Impairment in the EP/ELBW and T/NBW Cohorts According to T/NBW and WISC-IV Normative Distributions

<table>
<thead>
<tr>
<th>Outcome</th>
<th>EP/ELBW (n = 189)</th>
<th>T/NBW (n = 173)</th>
<th>Test for Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>General cognitive impairment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T/NBW distribution (106 ± 12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No impairment</td>
<td>49.2</td>
<td>87.1</td>
<td>(\chi^2 = 52.9, P &lt; .0001)</td>
</tr>
<tr>
<td>Mild impairment</td>
<td>35.8</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Major impairment</td>
<td>15.0</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>WISC-IV distribution (100 ± 15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No impairment</td>
<td>75.9</td>
<td>94.1</td>
<td>(\chi^2 = 22.7, P &lt; .0001)</td>
</tr>
<tr>
<td>Mild impairment</td>
<td>17.6</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td>Major impairment</td>
<td>6.4</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Reading impairment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T/NBW distribution (106 ± 14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No impairment</td>
<td>71.7</td>
<td>85.5</td>
<td>(\chi^2 = 14.5, P &lt; .001)</td>
</tr>
<tr>
<td>Mild impairment</td>
<td>19.6</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>Major impairment</td>
<td>8.7</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>WRAT3 distribution (100 ± 15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No impairment</td>
<td>81.0</td>
<td>91.9</td>
<td>(\chi^2 = 10.3, P = .001)</td>
</tr>
<tr>
<td>Mild impairment</td>
<td>14.7</td>
<td>7.8</td>
<td></td>
</tr>
<tr>
<td>Major impairment</td>
<td>4.3</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Spelling impairment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T/NBW distribution (104 ± 14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No impairment</td>
<td>73.5</td>
<td>89.5</td>
<td>(\chi^2 = 16.9, P &lt; .001)</td>
</tr>
<tr>
<td>Mild impairment</td>
<td>22.9</td>
<td>9.9</td>
<td></td>
</tr>
<tr>
<td>Major impairment</td>
<td>4.3</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>WRAT3 distribution (100 ± 15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No impairment</td>
<td>82.7</td>
<td>94.8</td>
<td>Cannot be calculated</td>
</tr>
<tr>
<td>Mild impairment</td>
<td>15.1</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td>Major impairment</td>
<td>2.2</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Arithmetic impairment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T/NBW distribution (99 ± 14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No impairment</td>
<td>72.0</td>
<td>87.2</td>
<td>(\chi^2 = 14.8, P &lt; .001)</td>
</tr>
<tr>
<td>Mild impairment</td>
<td>18.1</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>Major impairment</td>
<td>9.9</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>WRAT3 distribution (100 ± 15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No impairment</td>
<td>72.0</td>
<td>87.2</td>
<td>(\chi^2 = 14.8, P &lt; .001)</td>
</tr>
<tr>
<td>Mild impairment</td>
<td>18.1</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>Major impairment</td>
<td>9.9</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Behavioral problem</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T/NBW distribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>59.6</td>
<td>77.3</td>
<td>(\chi^2 = 12.3, P &lt; .001)</td>
</tr>
<tr>
<td>Borderline (80th percentile)</td>
<td>17.5</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td>Abnormal (90th percentile)</td>
<td>23.0</td>
<td>11.6</td>
<td></td>
</tr>
<tr>
<td>SDQ norms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>71.0</td>
<td>86.9</td>
<td>(\chi^2 = 12.4, P &lt; .001)</td>
</tr>
<tr>
<td>Borderline (80th percentile)</td>
<td>10.9</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>Abnormal (90th percentile)</td>
<td>18.0</td>
<td>7.6</td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as %, unless otherwise specified. Distribution values are presented as mean ± SD. Mild impairment for cognitive and academic scales refers to standard scores from −1 to −2 SDs relative to the normative or T/NBW distribution. Major impairment for cognitive and academic scales refers to standard scores less than −2 SDs relative to the normative or T/NBW distribution.
not all areas of social functioning are
in prosocial behavior, indicating that
notably, there was no group difference
in general social functioning. However,
with forming friendships and more
cognitive and behavioral problems
affected. Finally, within the EP/ELBW cohort, the 26- to 27-week GA subgroup was reported to exhibit more emotional problems by their parents than the <26-week GA subgroup. This finding was unexpected, the only signif-
ificant difference in this direction, and most likely reflects a chance
finding.
Few outcome studies of EP/ELBW chil-
dren report on large geographic
cohorts or achieve follow-up rates in
middle childhood of >90%; as such, our results are more generalizable
than most of the published research. Furthermore, many outcome studies
lack an appropriate control group, without which interpretation of results
for EP/ELBW children is impossible. Our study also has limitations. The T/NBW
group was matched to the EP/ELBW
group in terms of date of birth, gen-
der, mother’s country of birth, and
health insurance status, yet the control
group was more educated and the pri-
mary income earner was more likely to
have a skilled occupation. In addition,
the follow-up rate of the T/NBW group
was 87% in contrast to 94% for the
EP/ELBW group. To deal with these is-
sues, we adjusted for relevant social
demographic factors in secondary an-
lyses, but this action failed to alter any
of the statistical conclusions.

CONCLUSIONS
EP/ELBW children born in the late 1990s
continue to be significantly disadvan-
taged compared with T/NBW peers. Approximately 70% of EP/ELBW chil-
dren experience a cognitive, educa-
tional, or behavioral impairment at 8
years of age, and, alarmingly, nearly
50% exhibit multiple areas of concern.
The outcomes for those of <750 g
birth weight or <26 weeks’ GA were
similar to those with birth weights of
750 to 999 g or 26 to 27 weeks’ GA,
respectively. Efforts to reduce this
level of morbidity, such as neuro-
protective and neurorecovery inter-
ventions, need to be encouraged and
supported.

ACKNOWLEDGMENTS
This study was conducted by members of
the Victorian Infant Collaborative
Study Group, including Lex W Doyle,
MD, FRACP (Convenor), Royal Women’s
Hospital, Murdoch Childrens Research
Institute and University of Melbourne
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Institute and University of Melbourne
(Melbourne, Australia); Catherine Callanan, RN, Royal Women’s Hospital
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FRACP, Monash Medical Centre
(Melbourne, Australia); Margaret P
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Medical Centre (Melbourne, Australia);
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(Melbourne, Australia); Cinzia R De Luca,
PhD, Royal Women’s Hospital, Murdoch
Childrens Research Institute, and Uni-
versity of Melbourne (Melbourne, Aus-
tralia); Marie Hayes, RN, Monash
Medical Centre (Melbourne, Australia); Esther A Hutchinson, DPsychClinNeuro,

<table>
<thead>
<tr>
<th>Outcome</th>
<th>EP/ELBW (n = 175)</th>
<th>T/NBW (n = 169)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T/NBW distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No impairment</td>
<td>29.1 (51)</td>
<td>58.6 (98)</td>
</tr>
<tr>
<td>1 impairment</td>
<td>24.0 (42)</td>
<td>25.4 (43)</td>
</tr>
<tr>
<td>2 impairments</td>
<td>18.3 (32)</td>
<td>7.7 (13)</td>
</tr>
<tr>
<td>3 impairments</td>
<td>15.0 (28)</td>
<td>4.7 (8)</td>
</tr>
<tr>
<td>4 impairments</td>
<td>7.4 (13)</td>
<td>1.8 (3)</td>
</tr>
<tr>
<td>5 impairments</td>
<td>5.1 (9)</td>
<td>1.8 (3)</td>
</tr>
</tbody>
</table>

Data are presented as % (n).

*χ² (linear trend) = 58.4, P < .0001.

*χ² (linear trend) = 37.7, P < .0001.

It is also accepted that children born EP/
ELBW exhibit more behavioral prob-
lems.32 The most commonly reported
behavioral disorders are inattention,
including a diagnosis of attention-
deficit/hyperactivity disorder, anxiety,
and autism; this cluster of disorders
has been proposed to be the “preterm
behavior phenotype.”34 Our study sup-
ports this behavior phenotype, with
problems identified in attention, hy-
peractivity, and emotional symptoms.
Furthermore, our EP/ELBW group dis-
played more difficulties with peers,
reflecting the potential ramifications
of cognitive and behavioral problems
with forming friendships and more
general social functioning. However,
notably, there was no group difference
in prosocial behavior, indicating that
not all areas of social functioning are

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REFERENCES


An error occurred in this article by Hutchinson et al, titled “School-age Outcomes of Extremely Preterm or Extremely Low Birth Weight Children” published in the April 2013 issue of Pediatrics (2013;131[4]:e1053–e1061; originally published online March 18, 2013; doi:10.1542/peds.2012-2311). On page e1053, under Abstract, on line 5 and 6 of the Methods paragraph, this reads: “A term/normal birth weight (T/NBW) cohort was recruited comprising 199 infants with birth weights <2500 g or gestational age <37 weeks.” This should have read: “A term/normal birth weight (T/NBW) cohort was recruited comprising 199 infants with birth weights ≥2500 g or gestational age ≥37 weeks.”

doi:10.1542/peds.2013-1574


An error occurred in the article by Urbina et al, titled “Triglyceride to HDL-C Ratio and Increased Arterial Stiffness in Children, Adolescents, and Young Adults” published in the April 2013 issue of Pediatrics (2013;131[4]:e1082–e1090; originally published online March 4, 2013; doi:10.1542/peds.2012-1726). On pages e1085 and e1086, the legends for Figs 1, 2, and 3 read: “log TG/HDL-C stratified by BMI z-score group (lean = black, overweight/obese = gray).” These should have read: “(lean = blue, overweight/obese = red).” Furthermore, the color-coded legends in the box on the right of the figures was incorrect. They should have had a blue line for the lean subjects and a red line for the obese subjects.

doi:10.1542/peds.2013-1865


An error occurred in this article by Foster et al, titled “Feasibility and Preliminary Outcomes of a Scalable, Community-based Treatment of Childhood Obesity” published in the October 2012 issue of Pediatrics (2012;130[4]:652–659; originally published online September 17, 2012; doi:10.1542/peds.2012-0344). On page 656, in Table 2, this reads: “BMI z score Change at 24 Weeks Overall (n = 155) −0.062 ± 0.003; <13 y (n = 115) −0.068 ± 0.003; ≥13 y (n = 40) −0.042 ± 0.005.” This should have read: “BMI z score Change at 24 Weeks Overall (n = 155) −0.09 ± 0.01; <13 y (n = 115) −0.10 ± 0.03; ≥13 y (n = 40) −0.04 ± 0.05.”


A production error occurred in the print version of the article by Broder-Fingert et al, titled “Racial and Ethnic Differences in Subspecialty Service Use by Children With Autism” published in the July 2013 issue of Pediatrics (2013;132[1]:94–100; originally published online June 17, 2013; doi: 10.1542/2012-3888). On page 97, under Table 4, this reads: “20.32.” This should have read: “0.32.”

doi:10.1542/peds.2013-2034
School-age Outcomes of Extremely Preterm or Extremely Low Birth Weight Children

Esther A. Hutchinson, Cinzia R. De Luca, Lex W. Doyle, Gehan Roberts, Peter J. Anderson and for the Victorian Infant Collaborative Study Group

*Pediatrics* 2013;131:e1053; originally published online March 18, 2013; DOI: 10.1542/peds.2012-2311

The online version of this article, along with updated information and services, is located on the World Wide Web at:

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